

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant :	Satoru Okamoto	Art Unit :	1792
Serial No. :	10/689,617	Examiner :	Mahmoud Dahimene
Filed :	October 22, 2003	Conf. No. :	4799
Title :	METHOD FOR CLEANING PLASMA ETCHING APPARATUS, METHOD FOR PLASMA ETCHING, AND METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE		

**Mail Stop Amendment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

REPLY TO ACTION OF DECEMBER 19, 2008

Claims 1-95 are pending, with claims 1, 8, 15, 22, 29, 36, 43, 50, 57, 64, 71, 78, and 85 being independent.

Independent claims 1, 8, 29, 36, 57, 64, 71, 78 and 85, and their dependent claims, have been rejected as failing to comply with the enablement requirement. In particular, the Examiner asserts that the term " $\text{BO}_x$ " is not enabling because there is "no sufficient direction or guidance in the claim or the specification to determine which ' $\text{BO}_x$ ' is cleaned by the plasma." The Examiner then appears to assert that enablement further requires that the "x" in the term " $\text{BO}_x$ " be defined, and asserts that the statement in the specification indicating that an example of a " $\text{BO}_x$ " is " $\text{B}_2\text{O}_3$ " is incorrect because " $\text{BO}_x$  has only one B (boron) atom in the molecule, whereas  $\text{B}_2\text{O}_3$  has two." Applicants respectfully disagree.

$\text{BO}_x$  is a term that would have been understood by a person of ordinary skill in the art to mean "boron oxide." Applicants submit that the application specification is enabling with respect to the above claims because a person of ordinary skill in the art would have recognized, based on the term  $\text{BO}_x$ , that the contemplated process is applicable to any residue that comprises boron oxide. Contrary to the Examiner's apparent assertion, such an understanding does not require specification of a particular value for "x." Moreover, the Examiner's assertion that  $\text{B}_2\text{O}_3$  is not an example of a  $\text{BO}_x$  is premised on the incorrect assumption that there must be only one boron atom and that "x" must be a natural number. However, there may be more than one boron atom and "x" indicates the number of oxygen atoms relative to the number of boron atoms and

need not be a natural number. Thus,  $B_2O_3$  is an example of a particular  $BO_x$  in which there are two boron atoms and " $x$ "=1.5. Accordingly, applicants submit that the term  $BO_x$  is not only disclosed sufficiently such that a person of ordinary skill in the art would have been able to make and use the invention based on the disclosure, but also that the application's enabling disclosure is further bolstered by the disclosure of a particular concrete example of a  $BO_x$  being  $B_2O_3$ .

For at least these reasons, applicants request reconsideration and withdrawal of the rejection of claims 1, 8, 29, 36, 57, 64, 71, 78 and 85, and their dependent claims.

Independent claims 1, 8, 29, 36, 57, 64, 71, 78 and 85, and their dependent claims, have been rejected as being indefinite. Specifically, the Examiner states that "it is not clear what specific compound of the group " $BO_x$ " is claimed by the application since " $x$ " is not defined in the claims or the specification. For the reasons stated above, applicants submit that the term " $BO_x$ " is clear on its face without specification of a particular value of " $x$ " and that the term would have been understood by a person of ordinary skill in the art to mean "boron oxide." Accordingly, applicants request reconsideration and withdrawal of this rejection.

Claims 1-7, 15-21, and 57-95 have been rejected as being unpatentable over Chow (U.S. Patent No. 6,872,322) in view of Liu (U.S. Patent No. 6,566,270), Wolf (Silicon Processing for the VLSI Era), Choi (U.S. Patent Application Publication No. US2003/0207585) and Nakajima (U.S. Publication No. 2002/0053674). Claims 8-13 and 22-28 have been rejected as being unpatentable over Chow in view of Liu, Nakajima, Choi and Wolf. Claims 29-35 have been rejected as being unpatentable over Chow in view of Ye (U.S. Patent No. 5,756,400), Nakajima, Choi and Liu. Claims 43-56 have been rejected as being unpatentable over Chow in view of Liu, Nakajima, Choi, and Wolf. Claims 42, 49, 56, 62, and 69 have been rejected as being unpatentable over Chow in view of Liu, Lu (U.S. Patent No. 6,352,081), Izawa (U.S. Patent No. 6,842,658), Nakajima, Choi, and Wolf.

With respect to claims 1-13 and 29-35, neither Chow, Liu, Wolf, Choi, Nakajima, Ye, Lu, Izawa, nor any proper combination of the eight describes or suggests performing an etching in a chamber to form a first shape of a conductive film that is over a first substrate, placing a second or dummy substrate in the chamber and removing  $BO_x$  adhered to an inside of the

chamber, and then performing another etching in the chamber to form a second shape of the conductive film over the first substrate, as recited in independent claims 1, 8, and 29.

Chow discloses etching and cleaning being performed simultaneously in a process that uses a single substrate to form a semiconductor device. As acknowledged by the Examiner on page 7 of the Office Action, Chow does not describe or suggest cleaning a chamber between a first shape etching and a second shape etching. The Examiner relies on Choi for disclosing this feature. In particular, the Examiner refers to Choi for the general proposition that inserting a process chamber cleaning step between any two etching steps of the same layer in any manufacturing process is conventional and, therefore, it would have been obvious to insert such a chamber cleaning step between two of Chow's etching steps. Applicants respectfully disagree with such a broad characterization of Choi's teachings.

Choi teaches performing a process chamber cleaning step between two specific etching steps used in a specific manufacturing process. That is, the portion of Choi cited by the Examiner (which notably refers to a separate application of Tuman Allen III, now Patent No. 6,533,953) merely shows that one particular manufacturing process for silicon nitride spacers in a capacitive structure includes a chamber cleaning step between a first physical-type etching step of silicon nitride over a TEOS insulating film and a second chemical-type etching step of the remainder of the silicon nitride over the TEOS insulating film. The removal target of the chamber cleaning step is nitrogen-containing compounds created after the first etching step. In contrast, the claims at issue indicate that the first and second etchings are of a conductive film and the target of the chamber cleaning is BO<sub>x</sub> (i.e., boron oxide). While Choi may teach insertion of a chamber cleaning step between a first physical-type etch of silicon nitride and a second chemical-type etch of silicon nitride to remove nitrogen-containing compounds, nothing in Choi's teachings supports the broad assertion made by the Examiner that insertion of such a chamber cleaning step between any two different etching steps of the same layer is conventional such that a person of ordinary skill in the art would have found it obvious to modify the Chow process to insert a chamber cleaning step between two conductive film etching steps to remove BO<sub>x</sub>. Liu, Wolf, Nakajima, Ye, Lu and Izawa also fail to describe or suggest the above features.

For at least these reasons, applicants request reconsideration and withdrawal of the rejections of claims 1, 8 and 29, and their dependent claims.

Independent claim 15 recites performing a first etching in a chamber to form a first shape of a conductive film that is over a substrate, cleaning the chamber using a second substrate, and performing a second etching in the cleaned chamber to form a second shape of the conductive film. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claim 15 and its dependent claims because neither Chow, Liu, Wolf, Choi, Nakajima, Ye, Lu, Izawa, nor any proper combination of the eight describes or suggests this feature.

Independent claim 22 recites performing a first etching in a chamber to form a first shape of a conductive film that is over a substrate, cleaning the chamber using a dummy substrate, and performing a second etching in the cleaned chamber to form a second shape of the conductive film. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claim 22 and its dependent claims because neither Chow, Liu, Wolf, Choi, Nakajima, Ye, Lu, Izawa, nor any proper combination of the eight describes or suggests this feature.

Each of independent claims 43 and 50 recites etching a conductive film formed over a substrate in a chamber, cleaning the chamber using a second or a dummy substrate, and then etching the conductive film in the cleaned chamber. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claims 43 and 50, and their dependent claims, because neither Chow, Liu, Wolf, Choi, Nakajima, Ye, Lu, Izawa, nor any proper combination of the eight describes or suggests this feature

Independent claims 57, 64, 71, 78 and 85 each recite etching a conductive film in a chamber using an etching gas, generating plasma from a cleaning gas to remove  $\text{BO}_x$  adhered to an inside of the chamber as a residue, and then etching the conductive film in the cleaned chamber. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claims 57, 64, 71, 78 and 85, and their dependent claims, because

neither Chow, Liu, Wolf, Choi, Nakajima, Ye, Lu, Izawa, nor any proper combination of the eight describes or suggests this feature.

Claims 1, 2, 4, 5, 7-9, and 11-13 have been rejected as being unpatentable over Hoefler (U.S. Publication No. 2003/0222306) in view of Yeh (U.S. Publication No. 2002/0162827), Nakajima, and Choi. Claims 3, 6, 10, and 14 have been rejected as being unpatentable over Hoefler in view of Nakajima, Yeh, Choi, Nallan (U.S. Publication No. 2002/0137352) and Gabriel (U.S. Patent No. 6,815,359). Claims 15-21 and 22-28 have been rejected as being unpatentable over Hoefler in view of Yeh, Nakajima, Choi and Suzawa (U.S. Publication No. 2002/0171085).

With respect to claims 1-14, neither Hoefler, Yeh, Nakajima, Choi, Nallan, Gabriel, Suzawa, nor any proper combination of the seven describes or suggests performing an etching in a chamber to form a first shape of a conductive film that is over a first substrate, placing a second or dummy substrate in the chamber and removing  $\text{BO}_x$  adhered to an inside of the chamber, and then performing another etching in the chamber to form a second shape of the conductive film over the first substrate, as recited in independent claims 1 and 8.

In Hoefler, a semiconductor device 10 includes a substrate 12, and a semiconductor layer 18 over the substrate 12. See Hoefler at paragraphs 0014 and 0015. A conductive layer 34 is deposited by PVD on a gate dielectric 32 that is formed over the layer 18. See Hoefler at paragraph 0021 and Fig. 4. The conductive layer 34 is etched to form a gate electrode 36 and control electrodes 38. See Hoefler at paragraph 0022 and Fig. 5. However, Hoefler never suggests forming a first shape of the conductive layer 34 by etching in a chamber, generating plasma from the cleaning gas to remove  $\text{BO}_x$  adhered to an inside of the chamber as a residue, and then performing a second etching in the cleaned chamber to form a second shape of the conductive layer 34.

The Examiner relies on modifying Hoefler's process based on the teachings of various references to arrive at the claimed features. Notably, however, the Examiner again relies on Choi for the general proposition that inserting a process chamber cleaning step between any two etching steps of the same layer in any manufacturing process is conventional and, therefore, it

would have been obvious to insert such a chamber cleaning step between two etching steps in the modified process of Hoefler envisioned by the Examiner. For the reasons stated above, however, applicants submit that Choi's disclosure does not support the general proposition asserted by the Examiner and, therefore, that it would not have been obvious to insert a chamber cleaning step between two etching steps of Hoefler's modified process. Yeh, Nakajima, Nallan, Gabriel, and Suzawa also fail to describe or suggest this feature.

Applicants also note that on paragraph 13 of the Office Action, the Examiner asserts that Hoefler discloses the cleaning of an etching chamber as including removal of BO<sub>x</sub> from an inner surface of the etching chamber because Hoefler discloses that the substrate contains layers that include boron and oxygen. Applicants respectfully disagree with this assertion and contend that simply having a substrate that contains layers that include boron and oxygen does not indicate that the etching chamber will contain BO<sub>x</sub>.

For at least these reasons, applicants request reconsideration and withdrawal of these rejections of claims 1 and 8, and their dependent claims.

As stated previously, independent claim 15 recites performing a first etching in a chamber to form a first shape of a conductive film that is over a substrate, cleaning the chamber using a second substrate, and performing a second etching in the cleaned chamber to form a second shape of the conductive film. Independent claim 22 recites performing a first etching in a chamber to form a first shape of a conductive film that is over a substrate, cleaning the chamber using a dummy substrate, and performing a second etching in the cleaned chamber to form a second shape of the conductive film. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claims 15 and 22, and their dependent claims, because neither Hoefler, Choi, Yeh, Nakajima, Nallan, Gabriel, Suzawa, nor any proper combination of the seven describes or suggests these features.

Claims 1, 2, 5, 7-9, 11, 12, 29, 30, 32, 50, and 51 have been rejected as being unpatentable over Yamazaki (U.S. Publication No. 2002/0048829) in view of Chow, Nakajima, Yeh, and Choi. Claims 4, 13, and 34 have been rejected as being unpatentable over Yamazaki in view of Yeh, Nakajima, Choi, Chow, and Saito (U.S. Patent No. 6,221,200). Claims 3, 6, 10, 14,

31, 33, 35-49, and 52-84 have been rejected as being unpatentable over Yamazaki in view of Yeh, Nakajima, Chow, Choi, Nallan, and Gabriel.

With respect to claims 1-14 and 29-35, neither Yamazaki, Yeh, Nakajima, Chow, Choi, Nallan, Gabriel, Saito, nor any proper combination of the eight describes or suggests performing an etching in a chamber to form a first shape of a conductive film that is over a first substrate, placing a second or dummy substrate in the chamber and removing  $\text{BO}_x$  adhered to an inside of the chamber, and then performing another etching in the chamber to form a second shape of the conductive film over the first substrate, as recited in independent claims 1, 8, and 29.

In Yamazaki, a first conductive film 103 and a second conductive film 104 are formed over an insulation film 102, and the conductive films 103, 104 are subsequently etched. See Yamazaki at paragraphs 0011, 0012, and 0016. However, Yamazaki never describes or suggests that, after etching the conductive film 103 or 104, a chamber is cleaned to remove  $\text{BO}_x$  adhered to an inside of the chamber, and performing a second etching in the cleaned chamber. The Examiner again relies on Choi for the general proposition that inserting a process chamber cleaning step between any two etching steps of the same layer in any manufacturing process is conventional. For the reasons stated above, this reliance is misplaced and, accordingly, such a modification of Yamazaki's process would not have been obvious to a person of ordinary skill in the art. Yeh, Nakajima, Chow, Nallan, Gabriel and Saito do not remedy the failure of Yamazaki to describe or suggest this subject matter.

For at least these reasons, applicants request reconsideration and withdrawal of these rejections of claims 1, 8, and 29, and their dependent claims.

Independent claim 36 recites performing a first etching in a chamber to form a first shape of a conductive film, cleaning the chamber using a dummy substrate, and then performing a second etching in the cleaned chamber to form at least a second shape of the conductive film. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claim 36 and its dependent claims because neither Yamazaki, Yeh, Nakajima, Chow, Choi, Nallan, Gabriel, Saito, nor any proper combination of the eight describes or suggests these features.

As stated previously, independent claims 43 and 50 each recite etching a conductive film formed over a substrate in a chamber, cleaning the chamber using a second or a dummy substrate, and then etching the conductive film in the cleaned chamber. Independent claims 57, 64, 71, and 78 each recite etching a conductive film in a chamber using an etching gas, generating plasma from a cleaning gas to remove  $\text{BO}_x$  adhered to an inside of the chamber as a residue, and then etching the conductive film in the cleaned chamber. For at least the reasons described above, applicants request reconsideration and withdrawal of the rejection of claims 57, 64, 71 and 78 and their dependent claims because neither Yamazaki, Yeh, Nakajima, Chow, Choi, Nallan, Gabriel, Saito, nor any proper combination of the eight describes or suggests these features.

Claims 36-42 have been rejected as being unpatentable over Lu (U.S. Patent No. 6,352,081) in view of Chow, Choi, Nakajima, Liu, and Wolf.

As stated previously, independent claim 36 recites performing a first etching in a chamber to form a first shape of a conductive film, cleaning the chamber using a dummy substrate, and then performing a second etching in the cleaned chamber to form at least a second shape of the conductive film. Applicants request reconsideration and withdrawal of this rejection at least because neither Lu, Chow, Choi, Nakajima, Liu, Wolf, nor any proper combination of the six describe or suggest these features.

Lu relates to a dry cleaning method for removing deposited etch byproducts from surfaces of a semiconductor processing chamber after a copper etch process is performed in the chamber. See Lu at abstract. However, Lu never describes or suggests that the chamber is cleaned in part by removing  $\text{BO}_x$  adhered to an inside of the chamber and that a second etching in the cleaned chamber is performed to form a second shape of a conductive film on which a first shape was already formed by performing a first etching in the chamber. Lu merely explains that the cleaning method can be "performed between wafer processing runs without opening the processing chamber, thereby minimizing potential contamination to the chamber as well as chamber downtime." See Lu at abstract. The Examiner again relies on Choi for the general proposition that inserting a process chamber cleaning step between any two etching steps of the



same layer in any manufacturing process is conventional. For the reasons stated above, this reliance is misplaced and, accordingly, such a modification of Lu's process would not have been obvious to a person of ordinary skill in the art. Chow, Nakajima, Liu and Wolf do not remedy the failure of Yamazaki to describe or suggest this subject matter.

For at least these reasons, applicants request reconsideration and withdrawal of this rejection of claim 36 and its dependent claims.

Applicants do not acquiesce in the Examiner's characterizations of the art. For brevity and to advance prosecution, however, applicants may have not addressed all characterizations of the art and reserve the right to do so in further prosecution of this or a subsequent application. The absence of an explicit response by the applicants to any of the Examiner's positions does not constitute a concession of the Examiner's positions. The fact that applicants' comments have focused on particular arguments does not constitute a concession that there are not other arguments for patentability of the claims. All of the dependent claims are patentable for at least the reasons given with respect to the claims on which they depend.

Applicants submit that all claims are in condition for allowance.

The fees in the amount of \$130 for the one month extension are being paid concurrently herewith on the Electronic Filing System (EFS) by way of Deposit Account authorization. Please apply any other charges or credits to deposit account 06-1050.

Respectfully submitted,

Date: April 16, 2009

/ Roberto J. Devoto /  
Roberto J. Devoto  
Reg. No. 55,108

Fish & Richardson P.C.  
1425 K Street, N.W.  
11th Floor  
Washington, DC 20005-3500  
Telephone: (202) 783-5070  
Facsimile: (877) 769-7945